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SUBSTRATE STICKING METHOD AND ITS DEVICE

[Abstract]

PROBLEM TO BE SOLVED: To surely stick substrates together in a short time.

SOLUTION: Two substrates 33, 34 at least either one of which is provided with an adhesive 37 are oppositely arranged in a vacuum chamber 15, the inside of the vacuum chamber 15 is gradually exhausted and after that, made into a vacuum state by rapidly exhausting it. And the respective substrates 33, 34 are mechanically pressurized and stuck together and

gas is gradually introduced until the inside of the vacuum chamber 15 becomes prescribed pressure after the pressurization and the sticking. And when the inside of the vacuum chamber 15 reaches the prescribed pressure, the inside of the vacuum chamber is set as atmospheric pressure by rapidly introducing the gas.

[Claims]

[Claim 1]

A substrate adhesion method wherein two sheets of substrates at least one of which has an adhesive are positioned within a vacuum chamber of the vacuum state, pressurized and adhered together, wherein the substrates are disposed opposite to each other and are target adhesion subjects, the method comprising:

a first exhaust process in which each of the substrates is introduced into the vacuum chamber and slowly exhausted until the inside of the vacuum chamber obtains a predetermined pressure; and

a second exhaust process in which if the inside of the vacuum chamber obtains a predetermined pressure in the first exhaust process, the inside of the vacuum chamber is rapidly exhausted to become the vacuum state.

[Claim 2]

The substrate adhesion method as claimed in claim 1, further including:

a pressurization process of mechanically pressurizing each of the substrates in the vacuum state;

a first gas introduction process in which after the pressurization process, a gas is slowly introduced until the inside of the vacuum chamber having the vacuum state obtains a predetermined pressure; and

a second gas introduction process in which if the inside when the vacuum chamber obtains the predetermined pressure in the first gas introduction process, a gas is rapidly introduced to make the inside of the

vacuum chamber to include an atmospheric pressure.

[Claim 3]

A substrate adhesion method wherein two sheets of substrates at least one of which has an adhesive are positioned within a vacuum chamber of the vacuum state, pressurized and adhered together, wherein the substrates are disposed opposite to each other and are target adhesion subjects, the method comprising:

a pressurization process of mechanically pressurizing each of the substrates in the vacuum state;

a first gas introduction process in which after the pressurization process, a gas is slowly introduced until the inside of the vacuum chamber having the vacuum state obtains a predetermined pressure; and

a second gas introduction process in which if the inside when the vacuum chamber obtains the predetermined pressure in the first gas introduction process, a gas is rapidly introduced to make the inside of the vacuum chamber to include an atmospheric pressure.

[Claim 4]

A substrate adhesion apparatus including a vacuum chamber that pressurizes two sheets of substrates being a target adhesion subject therein and adhering the two substrates, a table that is disposed within the vacuum chamber and can move in a parallel direction to a plane of a corresponding substrate, which supports one of the two substrates, and a pressurization plate that is disposed within the vacuum chamber and can move in a perpendicular direction to a plane of a corresponding substrate,

which supports the other of the two substrates and is opposite to one of the substrates, the substrate adhesion apparatus comprising:

a gas exhaust means that evacuates the inside of the vacuum chamber and is disposed in the vacuum chamber; and

an exhaust speed varying means, disposed in the gas exhaust means, that changes the exhaust speed of a gas within the vacuum chamber and is disposed in the gas exhaust means.

[Claim 5]

The substrate adhesion apparatus as claimed in claim 4, wherein the exhaust speed varying means includes a first exhaust mechanism that slowly exhausts the vacuum chamber until the vacuum chamber obtains a predetermined pressure, and a second exhaust mechanism that rapidly exhausts the vacuum chamber of the vacuum chamber obtains a predetermined pressure.

[Claim 6]

The substrate adhesion apparatus as claimed in claim 4, further comprising:

a gas introduction means that allows the inside of a corresponding vacuum chamber to obtain an atmospheric pressure and is disposed in the vacuum chamber, and

an introduction speed varying means that changes the introduction speed of the gas into the vacuum chamber and is disposed in the gas introduction means.

[Claim 7]

A substrate adhesion apparatus including a vacuum chamber that

pressurizes two sheets of substrates being target adhesion subjects therein and adhering the two substrates, a table that is disposed within the vacuum chamber and can move in a parallel direction to a plane of a corresponding substrate, which supports one of the two substrates, and a pressurization plate that is disposed within the vacuum chamber and can move in a perpendicular direction to the plane of the corresponding substrate, which supports the other of the two substrates and is opposite to one of the substrates, the substrate adhesion apparatus comprising:

a gas introduction means that is disposed in the vacuum chamber and allows the inside of a corresponding vacuum chamber to obtain an atmospheric pressure; and

introduction speed varying means that is disposed in the gas introduction means and varies the introduction speed of a gas into the vacuum chamber.

[Claim 8]

The substrate adhesion apparatus as claimed in claim 6 or 7, wherein the introduction speed varying means includes a first gas introduction mechanism that slowly exhausts the vacuum chamber until the vacuum chamber obtains a predetermined pressure, and a second gas introduction mechanism that rapidly exhausts the vacuum chamber when the vacuum chamber obtains a predetermined pressure.

[Claim 9]

The substrate adhesion apparatus as claimed in claim 6 or 7, wherein the first gas introduction mechanism includes a pipe communicating with the vacuum chamber, and a valve that closes the

pipe, and

the second gas introduction mechanism has an atmospheric open valve that opens the vacuum chamber to the atmosphere.

[Claim 10]

The substrate adhesion apparatus as claimed in claim 9, wherein if the pressure within the vacuum chamber exceeds a predetermined pressure, force is applied to the atmospheric open valve in advance so that the atmospheric open valve can be opened.

[Title of the invention]

SUBSTRATE STICKING METHOD AND ITS DEVICE

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to a substrate adhesion method and apparatus thereof, wherein press force is effectively applied when two substrates are adhered together.

[0002]

[Description of the Prior Art]

In manufacturing a liquid crystal display panel, two sheets of glass substrates in which a transparent electrode or a thin film transistor array is disposed are adhered together with a very close distance of several μm (for example, 2μm) using a sealant having a ロ shape, which is provided at the outer edge of the substrates or an adhesive coated on a proper location of the outer circumference of the substrate (the substrates after

adhesion is referred to as "cell"). Each of the substrates and a space formed by the sealant or the adhesive is sealed using liquid crystal.

[0003]

Conventionally, a substrate adhesion method when performing sealing of liquid crystal includes Japanese Unexamined Patent Application Publication No. 2000-284295 discloses a method in which liquid crystal is dropped on one of substrates in which the sealant is patterned in a close pattern (口 shape) so that an inlet is not formed. Further, the other of the substrates is disposed on one of the substrates within the vacuum chamber, a distance between the other of the substrates and one of the substrates becomes narrow in the vacuum state, and the two substrates are pressurized and adhered together.

[0004]

To be more precise, in the substrate adhesion method disclosed in Japanese Unexamined Patent Application Publication No. 2000-284295, a bottom surface of a pressurization plate disposed within the vacuum chamber supports one of the substrates. In a same manner, the other of the substrates is supported on a table which is disposed within the vacuum chamber opposite to the pressurization plate. Further, the inside of the vacuum chamber is depressurized to become a vacuum state. A distance between the pressurization plate and the table becomes narrow, and the two substrates are adhered together.

[0005]

[Means for Solving the Problem]

In the substrate adhesion method disclosed in the exemplary prior

art, however, when making the inside of the vacuum chamber in the vacuum state, each of the substrates is torn by the flow of a gas exhausted within the vacuum chamber. Further, there is a possibility that positional deviation or damage such as crack can occur in the substrate supported in the pressurization plate or the table.

[0006]

Furthermore, since the pressure is rapidly decompressed, there is a problem in that moisture in the air within the vacuum chamber, and moisture adhered to a wall within the vacuum chamber, a film of the substrate, the liquid crystal and the like is frozen, having a bad influence on the cell. In this case, in order to avoid the bad influence on the cell, a waiting time until the frozen moisture is vaporized is needed. Thus, there is a problem in that time is taken in a substrate adhesion process.

[0007]

Furthermore, in the substrate adhesion method, the substrates are adhered together by applying pressure to each of the substrates using the pressurization plate. However, there is a problem in that the upper and lower substrates cannot be adhered together only with the pressure of the pressurization plate. For example, in the case of a small substrate, desired press force can be obtained only with the pressurization plate that gives mechanical press. If a substrate is large, press force becomes short and a sealant is not adhered in an effective way. This makes it impossible to adhere the substrates with a desired distance. Further, as such, if the sealant is not adhered in an effective way, a contact area between the substrates and the sealant becomes small, resulting in a poor contact

state. Furthermore, since liquid crystal does not diffuse into circumference of the sealant, there is a problem in that a large vacuum space is formed within the circumference.

[0008]

Accordingly, the present invention has been made in view of the above problems, and it is an object of the present invention to provide a substrate adhesion method and apparatus thereof, wherein generation of tearing of substrates or frozen moisture can be prevented, and adhesion can be thus accomplished certainly within a short time. Another object of the present invention to provide a substrate adhesion method and apparatus thereof, wherein a distance between substrates after adhesion can be positioned exactly, whereby adhesion is accomplished certainly within a short time.

[0009]

[Means for Solving the Problem]

In order to accomplish a first object, in the present invention according to Claim 1, there is provided a substrate adhesion method wherein two sheets of substrates at least one of which has an adhesive are positioned within a vacuum chamber of the vacuum state, pressurized and adhered together, wherein the substrates are disposed opposite to each other and are target adhesion subjects, the method including a first exhaust process in which each of the substrates is introduced into the vacuum chamber and slowly exhausted until the inside of the vacuum chamber obtains a predetermined pressure, and a second exhaust process in which if the inside of the vacuum chamber obtains a

predetermined pressure in the first exhaust process, the inside of the vacuum chamber is rapidly exhausted to become the vacuum state.

[0010]

In this case, in the present invention according to Claim 2, in order to accomplish a first object, in the substrate adhesion method according to Claim 1, the substrate adhesion method includes a pressurization process of mechanically pressurizing each of the substrates in the vacuum state, a first gas introduction process in which after the pressurization process, a gas is slowly introduced until the inside of the vacuum chamber having the vacuum state obtains a predetermined pressure, and a second gas introduction process in which if the inside when the vacuum chamber obtains the predetermined pressure in the first gas introduction process, a gas is rapidly introduced to make the inside of the vacuum chamber to include an atmospheric pressure.

[0011]

In order to accomplish the second object, in the invention according to Claim 3, a substrate adhesion method includes a pressurization process of mechanically pressurizing each of the substrates in the vacuum state, a first gas introduction process in which after the pressurization process, a gas is slowly introduced until the inside of the vacuum chamber having the vacuum state obtains a predetermined pressure, and a second gas introduction process in which if the inside when the vacuum chamber obtains the predetermined pressure in the first gas introduction process, a gas is rapidly introduced to make the inside of the vacuum chamber to include an atmospheric

pressure.

[0012]

In order to accomplish the first object, in the invention according to Claim 4, a substrate adhesion apparatus includes a vacuum chamber that pressurizes two sheets of substrates being a target adhesion subject therein and adhering the two substrates, a table that is disposed within the vacuum chamber and can move in a parallel direction to a plane of a corresponding substrate, which supports one of the two substrates, and a pressurization plate that is disposed within the vacuum chamber and can move in a perpendicular direction to a plane of a corresponding substrate, which supports the other of the two substrates and is opposite to one of the substrates. The substrate adhesion apparatus further includes gas exhaust means that evacuates the inside of the vacuum chamber and is disposed in the vacuum chamber, and exhaust speed varying means that changes the exhaust speed of a gas within the vacuum chamber and is disposed in the gas exhaust means.

[0013]

In this case, in the invention according to Claim 5, in the substrate adhesion apparatus according to Claim 4, the exhaust speed varying means includes a first exhaust mechanism that slowly exhausts the vacuum chamber until the vacuum chamber obtains a predetermined pressure, and a second exhaust mechanism that rapidly exhausts the vacuum chamber of the vacuum chamber obtains a predetermined pressure.

[0014]

Furthermore, in the invention according to Claim 6, in order to accomplish the second object, in the substrate adhesion apparatus according to Claim 4 or 5, the substrate adhesion apparatus further includes gas introduction means that allows the inside of a corresponding vacuum chamber of the vacuum state to become an atmospheric pressure and is disposed in the vacuum chamber, and introduction speed varying means that changes the introduction speed of the gas into the vacuum chamber and is disposed in the gas introduction means.

[0015]

In order to accomplish the second object, in the invention according to Claim 7, there is provided a substrate adhesion apparatus including a vacuum chamber that pressurizes two sheets of substrates being a target adhesion subject therein and adhering the two substrates, a table that is disposed within the vacuum chamber and can move in a parallel direction to a plane of a corresponding substrate, which supports one of the two substrates, and a pressurization plate that is disposed within the vacuum chamber and can move in a perpendicular direction to a plane of a corresponding substrate, which supports the other of the two substrates and is opposite to one of the substrates. The substrate adhesion apparatus further includes gas introduction means that is disposed in the vacuum chamber and allows the inside of a corresponding vacuum chamber of the vacuum state to become an atmospheric pressure, and introduction speed varying means that is disposed in the gas introduction means and varies the introduction speed of a gas into the vacuum chamber.

[0016]

In this case, in the invention according to Claim 8, in the substrate adhesion apparatus according to Claim 6 or 7, the introduction speed varying means includes a first gas introduction mechanism that slowly exhausts the vacuum chamber until the vacuum chamber obtains a predetermined pressure, and a second gas introduction mechanism that rapidly exhausts the vacuum chamber of the vacuum chamber obtains a predetermined pressure.

[0017]

Furthermore, in the invention according to Claim 9, in the substrate adhesion apparatus according to Claim 8, the first gas introduction mechanism includes a pipe communicating with the vacuum chamber, and a valve that closes the pipe, and the second gas introduction mechanism has an atmospheric open valve that opens the vacuum chamber to the atmosphere.

[0018]

Furthermore, in the invention according to Claim 10, in the substrate adhesion apparatus according to Claim 9, if the pressure within the vacuum chamber exceeds a predetermined pressure, force is previously applied to the atmospheric open valve so that the atmospheric open valve is opened.

[0019]

[Embodiment of the Invention]

[First Embodiment] A substrate adhesion apparatus according to the present invention will be described in connection with a first embodiment

with reference to Figs. 1 to 3.

[0020]

[Configuration of Substrate Adhesion Apparatus] As shown in Fig. 1, the substrate adhesion apparatus mainly includes a XYθ stage unit S1 that positions two substrates 33 and 34 being target adhesion subjects (hereinafter, the substrate 33 laid on a table 9 to be described later is referred to as a "lower substrate 33", and the substrate 34 supported by a pressurization plate 16 to be described later is referred to as a "upper substrate 34".), a substrate adhesion unit S2 that performs an adhesion operation on the substrates 33 and 34, and a Z-axis moving stage unit S3 that performs a first pressurization operation on the substrates 33 and 34, wherein the respective units S1, S2 and S3 are sequentially disposed on the mounting plate 1. In this case, the XYθ stage unit S1 is located on the mounting plate 1. The substrate adhesion unit S2 is supported by a first frame 2 having four support pole laid on the mounting plate 1. The Z-axis moving stage unit S3 is supported by a second frame 3 having four support poles disposed on the mounting plate 1. Hereinafter, the units S1, S2 and S3 will be described in detail.

[0021]

[XYθ Stage Unit] The XYθ stage unit S1 includes a X stage 4a disposed on the mounting plate 1, a Y stage 4b disposed on the X stage 4a, and a θ stage 4c disposed on the Y stage 4b. The X stage 4a of the present embodiment is constructed to move the Y stage 4b and the θ stage 4c in the right and left direction (a X-axis direction in Fig. 1) by means of a driving motor 5. Furthermore, the Y stage 4b is adapted to

move the θ stage 4c in the forward and backward direction (a Y-axis direction in Fig. 1) by means of a driving motor 6. Furthermore, the θ stage 4c is constructed to rotate in the θ direction shown in Fig. 1 against the Y stage 4b by means of the driving motor 8 with the rotary bearing 7 intervened therebetween.

[0022]

In this case, the table 9 on which the lower substrate 33 is located is fixed on the θ stage 4c through the support pole 10. Further, an arm 11 that surrounds a bottom side of the support pole 10 is disposed on the Y stage 4b through the rotary bearing 13 and the vacuum seal 14. This prevents the arm 11 from rotating according to the rotation of the support pole 10. Furthermore, a vacuum bellows 12 one end of which is fixed on the arm 11 and the other end of which is fixed to the bottom of the vacuum adhesion room 15, wherein the vacuum bellows is made of a resilient material of a bellow shape surrounding the support pole 10, is disposed between the arm 11 and a vacuum adhesion room 15 of the substrate adhesion unit S2. The vacuum bellows 12 maintains the vacuum state within the vacuum adhesion room 15 upon adhesion.

[0023]

Furthermore, in the present embodiment, it has been described that only one support pole 10 is disposed almost at the center of the table 9, the present invention is not limited thereto. For example, the support pole 10 can be disposed in plural if it can be rotated as much as a predetermined value of the table 9 by the θ stage 4c (the amount of deviation of a positional matching mark to be described later).

[0024]

[the substrate adhesion unit] The substrate adhesion unit S2 includes a vacuum adhesion room (vacuum chamber) 15 that adheres two sheets of substrates 33 and 34 under vacuum, a table 9 disposed within the vacuum adhesion room 15, and a pressurization plate 16 that is disposed an upper side of the table 9 within the vacuum adhesion room 15, as shown in Fig. 1. In this case, the lower substrate 33 in which an adhesive 37 or liquid crystal 39 to be described later is disposed is supported on the table 9. The upper substrate 34 adhered to the lower substrate 33 is supported on the pressurization plate 16.

[0025]

A first aperture 15a through the substrates 33 and 34 are go in out are disposed on the side of the vacuum adhesion room 15. Further, a gate valve 17 that closes the first aperture 15a is disposed in the vacuum adhesion room 15. In this case, the gate valve 17 is constructed to move in the up and down direction (a Z-axis direction in Fig. 1) by means of a cylinder 17A.

[0026]

Furthermore, first and second exhaust tubes 20a and 20b for evacuating the vacuum adhesion room 15are disposed under the vacuum adhesion room 15. Each of the exhaust tubes 20a and 20b is connected to a vacuum pump through a switch valve (not shown). In this case, the first exhaust tube 20a has a smaller diameter than that of the second exhaust tube 20b. For example, in the case of an exhaust tube whose cross section is almost circular, assuming that the diameter of the first exhaust

tube 20a is 1, the diameter of the second exhaust tube 20b is about 10 to 100 times. In this case, the diameter of the first exhaust tube 20a is designed to have the speed in which when the vacuum adhesion room 15 is evacuated from the first exhaust tube 20a, tearing of the substrates 33 and 34 due to the flow of a gas and frozen moisture due to scattering or decompression of liquid crystal on the lower substrate 33 are not generated. For example, when setting the diameter, the first exhaust tube 20a is experimented in pipes having different sizes. The first exhaust tube 20a having a diameter set based on the experiment results is disposed.

[0027]

Further, a plurality of elevation pins 35 for receiving the lower substrate 33 from a movable machine (not shown) or taking out a cell is put erect on the part of the table 9 within the vacuum adhesion room 15. The elevation pins 35 has one end (the bottom in Fig. 1) in which the cylinder 36 is disposed. The elevation pins 35 are constructed to move in the up and down direction within a through hole formed in the table 9 by means of the cylinder 36.

[0028]

Furthermore, a pipe 21 is disposed on the vacuum adhesion room 15and serves to return the vacuum state within the vacuum adhesion room 15 to an atmospheric pressure. A valve 22 is disposed in the middle of the pipe 21 and serves to introduce or preclude a gas (air) within the vacuum adhesion room 15. In this case, a pressure source (e.g., a pump) (not shown) is coupled to the pipe 21. It is thus possible to control the introduction speed of the gas into the vacuum adhesion room 15.

Furthermore, the pressure source may not be disposed, if needed.

[0029]

Further, an atmospheric open valve 23 having a sheet shape, which closes the second aperture 15b formed in the vacuum adhesion room 15, and a cylinder 24 that separates the atmospheric open valve 23 from the second aperture 15b are disposed on the side of the vacuum adhesion room 15 (an opposite side to the side where the gate valve 17 is provided). As such, as the atmospheric open valve 23 separates the atmospheric open valve 23 from the second aperture 15b, the inside of the vacuum adhesion room 15 can be rapidly returned to the atmospheric pressure. In this case, in the case where the cross section of the pipe 21 is almost circular, assuming that the diameter of the pipe 21 is 1, it is preferred that the diameter of the second aperture 15b is 5 or higher.

[0030]

Furthermore, a plurality of windows 25 for monitoring positional matching marks of the substrates 33 and 34 through a mark recognition hole (not shown), which is formed in the pressurization plate 16, is disposed on the vacuum adhesion room 15. In this case, in monitoring the positional matching marks, the recognition camera 26 shown in Fig. 1 is used. Deviation of the positional matching marks of the substrates 33 and 34 is measured using the recognition camera 26.

[0031]

Then, electrostatic adsorption electrodes (not shown) and a plurality of vacuum adsorption holes 9a, for adsorbing the lower substrate 33 by way of electrostatic or vacuum adsorption, are disposed in the table

9.

[0032]

In the present embodiment, the electrostatic adsorption electrodes are almost square flat panel electrodes and are inserted into two almost square concave portions, respectively, which are formed at both ends of the table 9. Further, the electrostatic adsorption electrodes have their surface (a surface side of the table 9) covered with dielectric substance. The principle surface of dielectric substance is formed to face the surface of the table 9. As such, the electrostatic adsorption electrodes disposed in the table 9 are coupled through a switch for applying a positive or negative DC power. For this reason, if a positive or negative voltage is applied to each of the electrostatic adsorption electrodes, negative or positive charges are generated in the principle surface of the dielectric substance. Further, the lower substrate 34 is adsorbed to the table 9 in an electrostatic manner due to crone power generating between the lower substrate 34 and a transparent electrode film formed in the lower substrate 34. In this case, voltages applied to the electrostatic adsorption electrodes can have the same polarity or a different polarity.

[0033]

Furthermore, in the event that the inside of the substrate adhesion room 15 is atmospheric, suction adsorption can be preferably performed using the vacuum adsorption holes 9a. This is because if electrostatic adsorption is performed, a discharge phenomenon is generated due to static electricity, damaging the lower substrate 34 or the table 9 when an air layer exists between the lower substrate 34 and the table 9. For this

reason, for example, since the circumstance is under atmosphere when the lower substrate 34 is first adhered to the table 9, it is preferred that suction adsorption is performed, and electrostatic adsorption is then performed after a decompression room is decompressed to the degree where the discharge phenomenon is not generated while the decompression room is decompressed.

[0034]

Thereafter, each of the vacuum adsorption holes 9a is coupled to an adsorption valve (not shown) disposed outside the substrate adhesion room 15 through the pipe 18, and is also coupled to a vacuum pump (not shown) through the adsorption valve. In this case, a bypass pipe for opening the atmosphere is disposed in the middle of the pipe 18 through a valve for releasing vacuum adsorption. The adsorption state is forcedly released by opening the valve for releasing vacuum adsorption. The table 9 constructed above is fixed on the θ stage 4c through the support pole 10 as described above.

[0035]

Furthermore, in the same manner as the table 9, electrostatic adsorption electrodes and a plurality of vacuum adsorption holes 16a for adsorbing the upper substrate 34 are disposed in the pressurization plate 16. At this time, as will be described later, if the substrate adhesion room 15 is decompressed with the upper substrate 34 being adsorbed in the pressurization plate 16, there is a possibility that the upper substrate 34 may be dropped since the adsorption force becomes weal. For this reason, a substrate support ring (not shown) for receiving the upper

substrate 34 at a location right below the pressurization plate 16 is disposed within the substrate adhesion room 15. The substrate support ring can be disposed corresponding to two edge portions being a diagonal location of the upper substrate 34, and is supported by a shaft extending from the top of the substrate adhesion room 15 to the bottom thereof.

[0036]

In particular, though not shown, a shaft is inserted into a through hole formed on the top of the substrate adhesion room 15. The shaft is constructed to rotate around its shaft center and to move up and down. In this case, the shaft is surrounded with a vacuum seal in order to prevent vacuum leakage from occurring in the inside of the substrate adhesion room 15. The rotation is performed by a rotary actuator (not shown) coupled to the end of the shaft, and the up and down movement is carried out by an elevation actuator (not shown) coupled to the end of the shaft in the same manner. As such, as the shaft is rotated and moved up and down, the substrates 33 and 34 are adhered. The substrate support ring can be removed so that a liquid crystal agent dropped on the lower substrate 33 does not interfere the diffusion of the principle surface of the substrates 33 and 34 when the liquid crystal agent diffuses.

[0037]

Each of the vacuum adsorption holes 16a is coupled to the adsorption valve (not shown) disposed outside the substrate adhesion room 15 through the pipe 19, and is also coupled to the vacuum pump (not shown) through the adsorption valve. In this case, in the same

manner as the table 9, a bypass pipe for opening the atmosphere is disposed in the middle of the pipe 18 through the valve for releasing vacuum adsorption. Further, the adsorption state is forcedly released by opening the valve for releasing vacuum adsorption. The pressurization plate 16 constructed above is fixed to a movable base 29, which will be described later, of the Z-axis moving stage unit S3 through a plurality of support poles 27.

[0038]

In this case, a vacuum bellows 28 made of a bellow elastic material that surrounds the support pole 27 is formed between the vacuum adhesion room 15and the movable base 29. One end of the vacuum bellows 28 is fixed on the vacuum adhesion room 15and the other end of the vacuum bellows 28 is fixed to the bottom of the movable base 29. Thereby, the vacuum bellows 28 maintains the vacuum state within the vacuum adhesion room 15 upon adhesion.

[0039]

[Z-axis Moving Stage Unit] The Z-axis moving stage unit S3 includes a movable base 29 that supports the pressurization plate 16, a linear guide 30 disposed at both ends of the movable base 29, a rail 3a that engages the linear guide 30 and extends in the up and down direction (a Z-axis direction in Fig. 2) disposed in the frame 3, an electric motor 32 having an output axis of a Z-axis direction, and a ball screw 31 that has one end engaged with the movable base 29 and the other end engaged with the output axis of the electric motor 32. As such, since the Z-axis moving stage unit S3 is constructed, the driven electric motor 32 moves the

movable base 29 in the up and down direction along the rail, moving the pressurization plate 16 up and down.

[0040]

[Operation of Substrate Adhesion Apparatus] The operation of the substrate adhesion apparatus according to the present embodiment will be below described. In this case, a case where a substrate for a liquid crystal panel is used as a substrate being a target adhesion subject will be described as an example.

[0041]

First, in order to seal liquid crystal within a defined frame when two substrate are adhered together, an adhesive of a circumference shape is coated so that it is not disconnected. A small amount of liquid crystal is then dropped on one of the two substrate. The substrate on which the liquid crystal is dropped will be referred to as a lower substrate 33.

[0042]

The outer circumference of the upper substrate 34 toward the bottom of a film is adsorbed using the hand of a moving machine (not shown) disposed outside the vacuum adhesion room 15. Further, the gate valve 17 disposed in the first aperture 15a of the vacuum adhesion room 15 is opened and the hand of the moving machine is inserted from the vacuum adhesion room 15 into the first aperture 15a. The electric motor 32 is driven to lower the pressurization plate 16, which is then pressed against the upper substrate 34. Thereafter, suction adsorption of the hand is released, and the vacuum pump operates to adhere the upper substrate 34 to the pressurization plate 16 through the suction adsorption hole 16a.

If the adsorption of the upper substrate 34 is completed, the hand is removed out of the vacuum adhesion room 15.

[0043]

Then, the cylinder 36 is driven to raise each of the elevation pins 35 up so that the front end of each of the elevation pins 35 is projected from the surface of the table 9. Further, the outer circumference of the lower substrate 33 on which a plane where the liquid crystal is dropped is a top surface is adsorbed from the bottom of the hand of the moving machine. The hand is inserted into the vacuum adhesion room 15 to move the lower substrate 33 on each of the elevation pins 35. If the movement of the lower substrate 33 is finished, the hand is removed out of the vacuum adhesion room 15 and the gate valve 17 is closed. Thereafter, each of the elevation pins 35 is lowered to locate the lower substrate 33 on the table 9. The vacuum pump is driven to vacuum-adsorb the lower substrate 33 to the table 9 through the suction adsorption hole 9a.

[0044]

If the adsorption of the substrates 33 and 34 to the table 9 and the pressurization plate 16 is thus completed, the valve on the part of the first exhaust tube 20a is opened to slowly discharge a gas within the vacuum adhesion room 15. To be more precise, in the present embodiment, in an initial state of the apparatus, the first and the second exhaust tubes 20a and 20b are all closed by means of the switch valve. If the adsorption of the substrates 33 and 34 is completed, the switch valve is switched so that the first exhaust tube 20a is opened and the second exhaust tube 20b is closed, slowly exhausting the gas within the vacuum adhesion room 15.

In this case, since the gas is slowly exhausted using the first exhaust tube 20a having the above diameter, it is possible to prevent tearing of the substrates 33 and 34 due to the flow of a gas, frozen moisture due to scattering or decompression of liquid crystal on the lower substrate 33.

[0045]

Thereafter, when the inside of the vacuum adhesion room 15 obtains a predetermined pressure due to the exhaust by the first exhaust tube 20a, more particularly, atmospheric pressure within the vacuum adhesion room 15, which is measured using a pressure gauge (not shown) becomes a pressure that does not tearing of the substrate and generation of scattering or frozen moisture of liquid crystal although the exhaust speed is increased (for example, the upper substrate 34 adsorbed by vacuum adsorption force is decompressed to the pressure of the degree which does not fall from the pressurization plate 16), the valve of the first exhaust tube 20a is shut.

[0046]

Further, the valve of the second exhaust tube 20b is opened to rapidly decompress the inside of the vacuum adhesion room 15 until the pressure for adhering the substrates 33 and 34 (in the present embodiment, about 5×10^{-3}Torr). In this case, since atmospheric pressure within the vacuum adhesion room 15 becomes lower than the vacuum adsorption force of the upper substrate 33 under the pressure, the upper substrate 33 is fallen off from the pressurization plate 16. However, the aforementioned substrate support ring is provided at the bottom of the pressurization plate 16. The upper substrate 33 is supported by the

aforementioned rotary actuator or the elevation actuator through movement of the substrate support ring. Thus, the upper substrate 33 is not fallen off from the pressurization plate 16.

[0047]

If the decompression within the above-described vacuum adhesion room 15 is completed, the substrates 33 and 34 are electrostatic-adsorbed by applying a voltage to the table 9 and the electrostatic adsorption electrode of the pressurization plate 16 so that the substrates 33 and 34 can be adsorbed to the table 9 and the pressurization plate 16, respectively, under vacuum. Thereafter, the electric motor 32 is driven to lower the movable base 29, and to make the upper substrate 34 approach the lower substrate 33. Further, positional deviation between the substrates 33 and 34 is measured by monitoring the positional matching marks provided in the substrates 33 and 34 using the recognition camera 26. The operation of each of the X stage 4a, the Y stage 4b and the θ stage 4c is controlled based on the measurement, and the table 9 is moved in a parallel way, thus exactly positioning the lower substrate 33 and the upper substrate 34.

[0048]

If such positioning is completed, the movable base 29 is further lowered, and first pressurization is then performed in which the upper substrate 34 presses the adhesive. After the first pressurization, the application of the voltage to the electrostatic adsorption electrode of the pressurization plate 16 is stopped, and the electric motor 32 is driven to raise the pressurization plate 16 up.

[0049]

In this case, the state of each of the substrates 33 and 34 after the first pressurization is shown in Fig. 2. In this case, a distance between the substrates 33 and 34 is about 15, but is not a desired distance. Due to this, the amount of compression in the adhesive 37 is low, and a contact area between the substrates 33 and 34 in the adhesive 37 is small (since the length of the contact portion 38 is short), a contact state becomes incomplete. In addition, since the liquid crystal 39 does not disperse within the edge of the adhesive 37, a great vacuum space unit 40 is formed between the liquid crystals 39.

[0050]

The state of each of the substrates 33 and 34 corresponds to a case where the pressure of the pressurization plate 16 in the aforementioned conventional example is short. In this case, in order to apply a desired pressure, a high pressure can be applied to the apparatus itself. Since the apparatus becomes bulky, however, the cost increases since the entire apparatus must be reconstructed.

[0051]

In this case, the pressure within the vacuum adhesion room 15 varies from the vacuum state to the atmospheric pressure, the space portion (the aforementioned vacuum space unit 40) between the substrates 33 and 34 is in a vacuum state, and a high pressure is uniformly applied to each of the substrates 33 and 34 from the outside. For example, if the size of each of the substrates 33 and 34 is 1200 mm× 1000 mm, the space portion between the substrates 33 and 34 is applied

with force of 121.6 kN when being applied with the atmospheric pressure in the vacuum state. For this reason, in the present embodiment, the distance between the substrates is made to 5μm, preferably below 4 μm by performing secondary pressurization while the size of the apparatus is the same as those of the prior art.

[0052]

As mentioned above, if the pressure within the vacuum adhesion room 15 is changed from the vacuum state to the atmospheric pressure after first pressurization is completed, the pressure can be almost uniformly applied to the substrates 33 and 34. If the pressure within the vacuum adhesion room 15 is abruptly changed from the vacuum state to the atmospheric pressure, the adhesive 37 is not sufficiently pressurized as described above. Thus, the gas tears the adhesive 37 and enters the vacuum space unit 40, resulting in a defective liquid crystal substrate. For this reason, in the present embodiment, the valve 22 of the pipe 21 is opened after the first pressurization, and the gas pressurized from the pressure source coupled to the pipe 21 is introduced into the vacuum adhesion room 15, so that the pressure slowly changes to the atmospheric pressure. If the inside of the vacuum adhesion room 15 slowly returns to the atmospheric pressure, the pressure is slowly applied to the substrates 33 and 34, which are then slowly compressed by the adhesive 37. Thus, the contact area between the adhesive 37 and each of the substrates 33 and 34 slowly expands. By doing so, since a difference between the internal pressure of the vacuum space unit 40 and the pressure within the vacuum adhesion room 15 becomes high slowly, there

is no possibility that the introduced gas tears the adhesive 37 and enters the vacuum space unit 40.

[0053]

Each of the substrates 33 and 34 in this state is shown in Fig. 3. The distance between the substrates 33 and 34 shown in Fig. 3 is about 10 μm. In this case, the adhesive 37 is compressed into a shape close to that from Fig. 2 to Fig. 3 if the gas is introduced into the vacuum adhesion room 15, as described above. The viscosity of the adhesive is lowered due to thixotropy property. In the present embodiment, in a state where the viscosity of the adhesive 37 is lowered, the atmospheric open valve 23 for returning the inside of the vacuum adhesion room 15 to the atmospheric pressure is opened to apply the pressure to each of the substrates 33 and 34. In particular, when a pressure gauge provided in the vacuum adhesion room 15 detects that the pressure exceeds a predetermined pressure, the valve 22 is shut and the cylinder 24 operates to open the atmospheric open valve 23. Thus, the pressure is added to the substrates 33 and 34, thus completing adhesion. For example, the predetermined pressure can be a pressure that allows the introduced gas not to tear the adhesive 37 and not enter the vacuum space unit 40.

[0054]

As such, since the inside of the vacuum adhesion room 15 rapidly returns to the atmospheric pressure, the contact area of the adhesive 37 becomes wider against each of the substrates 33 and 34, and the sealing property is improved accordingly. Thus, there is no possibility that a gas between the substrates 33 and 34 may tear the adhesive 37. Furthermore,

the adhesive 37 is rapidly compressed since the viscosity thereof is low, and the liquid crystal 39 is pressurized and compressed and then spread. Accordingly, an adhesion time of each of the substrates 33 and 34 becomes short.

[0055]

As described above, if the adhesion is completed and the pressure within the vacuum adhesion room 15 becomes the atmospheric pressure, the gate valve 17 is opened. Further, the application of the voltage to the electrostatic adsorption electrode of the table 9 is stopped. After suction in the vacuum adsorption holes 9a is released, each of the elevation pins 35 is raised to push up the cell from the table 9. Thereafter, the hand of the moving machine is inserted from the first aperture 15a into the bottom of the cell (between the cell and the table 9). The cell is moved on the hand and is then taken out of the vacuum adhesion room 15.

[0056]

In this case, the cylinder 24 that moves the aforementioned atmospheric open valve 23 is set to open the atmospheric open valve 23 even when the pressure within the vacuum adhesion room 15 is in the atmospheric pressure. Thereby, although a user forgets closing the valve 22 in the aforementioned predetermined pressure, the atmospheric open valve 23 is automatically opened when the pressure within the vacuum adhesion room 15 becomes the atmospheric pressure. Therefore, the pressure within the vacuum adhesion room 15 can be controlled not to exceed the atmospheric pressure. Further, due to this, the accuracy of the cell is not degraded and the stability of the work can be secured.

[0057]

Furthermore, in the present embodiment, it has been described that the first and second exhaust tubes 20a and 20b having different diameters are switched by the switch valve in order to change the exhaust path, and the exhaust speed is thus controlled. The present invention is, however, not limited thereto. For example, only one exhaust tube can be formed without forming the two exhaust tubes 20a and 20b as in the present embodiment. The exhaust tube can be connected to the vacuum pump and the exhaust speed can be then controlled using the vacuum pump. In this case, the exhaust tube has a thick diameter (i.e., the diameter the second exhaust tube 20b of the present embodiment).

[0058]

Thereafter, a modification example of the aforementioned secondary pressurization will be described. In this case, unlike the secondary pressurization, force of a direction that opens the atmospheric open valve 23 is previously applied to the cylinder 24. The force refers to small force of the degree in which the atmospheric open valve 23 continues to close the second aperture 15b (continues to maintain the vacuum state within the vacuum adhesion room 15) when the inside of the vacuum adhesion room 15 becomes a vacuum state. In particular, the force of a direction, which is previously applied to the cylinder 24 and opens the atmospheric open valve 23, is set lower than tension force that is applied from the vacuum adhesion room 15 of the vacuum state to the atmospheric open valve 23.

[0059]

In this state, the valve 22 is opened and the pressure source coupled to the pipe 21 is then driven to slowly introduce a gas into the vacuum adhesion room 15. If the gas continues to be introduced, the vacuum degree within the vacuum adhesion room 15 becomes low, and the tension force becomes smaller than the force that is previously applied to the aforementioned cylinder 24 and will open the atmospheric open valve 23, the atmospheric open valve 23 is automatically closed and the pressure within the vacuum adhesion room 15 rapidly returns to the atmospheric pressure. As such, as force is previously applied to the atmospheric open valve 23, the inside of the vacuum adhesion room 15 does not exceed the atmospheric pressure. It is thus possible to secure the stability without causing the accuracy of a cell to degrade. That is, the atmospheric open valve 23 can serve as a safety valve. Further, even in the present embodiment, the pressure source is not necessarily provided.

[0060]

Hereinafter, another modification example of the secondary pressurization will be described. In the present modification example, force of a direction that closes the atmospheric open valve 23 is previously applied to the cylinder 24, unlike the modification example. The force refers to one that maintains the close state of the atmospheric open valve 23 until the pressure acts when the pressure within the vacuum adhesion room 15 becomes higher than the atmospheric pressure. In this case, the force applied to the cylinder 24 is decided according to the size of each of the substrates 33 and 34. The greater the force necessary for adhering the substrates 33 and 34, the greater the force.

[0061]

As described above, the valve 22 is opened with force previously being applied to the cylinder 2, and a pressure source coupled to the pipe 21 is driven to slowly introduce a gas into the vacuum adhesion room 15. The gas is introduced until the pressure within the vacuum adhesion room 15 exceeds the atmospheric pressure, in particular, when the pressure exceeds force previously set in the cylinder 24. If the pressure exceeds force previously set in the cylinder 24, the atmospheric open valve 23 is opened to return the pressure within the vacuum adhesion room 15 to the atmospheric pressure. As such, force of a direction that closes the atmospheric open valve 23 is previously applied to the cylinder 24. Thus, even when high pressure is needed in adhesion of the substrates 33 and 34 since the substrates 33 and 34 is great, force necessary for adhering the substrates 33 and 34 can be uniformly applied by controlling the force set in the cylinder 24.

[0062]

In each of the modification examples, adhesion is finished through the pressure, as described above. If the pressure within the vacuum adhesion room 15 becomes the atmospheric pressure, the valve 22 is closed and the gate valve 17 is opened. Further, after suction in the vacuum adsorption holes 9a is released by shutting a voltage applied to an electrostatic adsorption electrode of the table 9, each of the elevation pins 35 is raised to push a cell over the table 9. Thereafter, the hand of the moving machine is inserted between the first aperture 15a and the bottom of the cell (between the cell and the table 9). The cell is then moved on the

hand to discharge the vacuum adhesion room 15 to the outside.

[0063]

[Second Embodiment] Hereinafter, a substrate adhesion apparatus according to the present invention will be described in connection with a second embodiment with reference to Fig. 4.

[0064]

The substrate adhesion apparatus is the same as that of the first embodiment except for the following points. More particularly, in the first embodiment, the gate valve 17 and the atmospheric open valve 23 are provided separately. In the present embodiment, however, the atmospheric open valve 23 is also used the gate valve 17. The construction thereof will be described in detail.

[0065]

The construction of the gate valve 17 and atmospheric open valve 23 according to the present embodiment, which are provided for a combined use, includes a gate valve 41 that closes the first aperture 15a of the vacuum adhesion room 15, and can move in the up and down direction, a plurality of shafts 42 disposed on an opposite side to a closed surface of the gate valve 41, a cylinder 44 that is disposed on each of the shafts 42 and can move the gate valve 41 in a direction that is separated from the first aperture 15a (a X direction in Fig. 4), an arm 45 which has a L-shaped cross section shape and has a linear guide 43 that slides the shaft 42 disposed to surround each of the shafts 42 in an axis direction, and a cylinder 46 that moves the gate valve 41 fixed to the arm 45 in the up and down direction. In this case, the second aperture 15b shown in the

vacuum adhesion room 15 of the first embodiment is not formed in the vacuum adhesion room 15 of the present embodiment.

[0066]

The adhesion operation of each of the substrates 33 and 34 in the apparatus constructed above according to the present embodiment is the same as those of the first embodiment except for the operations related to the gate valve 17 and the atmospheric open valve 23 in the aforementioned first embodiment. In this case, only different points in the operation of the present embodiment will be described.

[0067]

First, in the case where each of the substrates 33 and 34 is introduced into the vacuum adhesion room 15 or a case where a cell is taken out from the vacuum adhesion room 15, the cylinder 46 is drive to move the gate valve 41 up and down together with the cylinder 44 or the arm 45. In the event that the pressure within the vacuum adhesion room 15 is rapidly returned to the atmospheric pressure upon secondary pressurization, the cylinder 44 is driven to separate the gate valve 41 from the vacuum adhesion room 15. The first aperture 15a is also opened to introduce the atmosphere into the vacuum adhesion room 15. In this case, force can be previously applied to the cylinder 44 as in the modification example of the aforementioned first embodiment, and the gate valve 41 can be operated in the same manner as the modification example.

[0068]

As such, the function of the atmospheric open valve 23 according to the aforementioned first embodiment has the gate valve 41, thus

reducing the number of components. Furthermore, an apparatus can be miniaturized and can be easily assembled.

[0069]

[Effect of the Invention]

According to a substrate adhesion method and apparatus thereof in accordance with the present invention, two sheets of substrates are introduced into a vacuum chamber, and the vacuum chamber is then slowly exhausted until the inside of the vacuum chamber obtains a predetermined pressure. Further, when the pressure becomes the predetermined pressure, the vacuum chamber is rapidly exhausted to become a vacuum state. It is thus possible to prevent tearing of substrates or frozen moisture. Accordingly, adhesion can be completed surely within a short time.

[0070]

Furthermore, substrates are mechanically pressurized and adhered. A gas is slowly introduced until the inside of a vacuum chamber of a vacuum state obtains a predetermined pressure. Further, when the pressure becomes the predetermined pressure, the gas is rapidly introduced to make the inside of the vacuum chamber in an atmospheric pressure. It is thus possible to exactly position a distance between the adhered substrates, and to complete adhesion within a short time in a sure way. Accordingly, an excellent substrate adhesion method and apparatus thereof unlike the prior art can be obtained.

[Description of Drawings]

Fig. 1 is a partial cross-sectional view illustrating the construction of a substrate adhesion apparatus according to a first embodiment of the present invention.

Fig. 2 is an explanatory view showing each of substrates after first pressurization in the present embodiment.

Fig. 3 is an explanatory view showing each of substrates before release of the atmosphere upon secondary pressurization in the present embodiment.

Fig. 4 is a partial cross-sectional view illustrating the construction of a substrate adhesion apparatus according to a second embodiment of the present invention.

[Description of Numerals]

9: Table

15: Vacuum adhesion room (vacuum chamber)

16: Pressurization plate

20a: First exhaust tube (second exhaust mechanism of exhaust speed varying means)

20b: Second exhaust tube (first exhaust mechanism of exhaust speed varying means)

21: Pipe (first gas introduction mechanism of introduction speed varying means)

22: Valve (first gas introduction mechanism of introduction speed varying means)

23: Atmospheric open valve (second gas introduction mechanism of

introduction speed varying means)

33,34: Substrate

37: Adhesive